

points out, food has both cultural and economic dimensions.

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Who Owns Outer Space? International Law, Astrophysics, and the Sustainable Development of Space. By Michael Byers and Aaron Boley. Cambridge, UK: Cambridge University Press, 2023. Pp. xii, 407. Index. doi:10.1017/ajil.2024.32

Who Owns Outer Space? is a collection of co-authored essays addressing the legal and policy implications of emerging practices in the exploration and use of outer space. Specifically, the book examines a selection of “grand challenges”—that is to say, “problems that exist on a scale that implicates all of humanity and must be solved for our civilization to prosper and, indeed, in some cases, to survive” (p. 6). Through employing this novel angle of inquiry to analyze critical issues of space law and policy, the book enriches the international space law literature in three ways. First, it provides a multidisciplinary analysis that successfully blends legal, policy, and scientific considerations. This approach reflects the authors’ areas of expertise: Michael Byers is professor of global politics and international law at the University of British Columbia while Aaron Boley is professor of planetary astronomy at the same institution. The book’s analysis fully integrates the authors’ expertise in astrophysics, international law, and international relations, and contributes to the nascent field of multidisciplinary studies on outer space—sitting alongside titles such as Charles Cockell’s *The Institutions of Extraterrestrial Liberty*¹—by providing a STEM-informed analysis of international space law matters. Second, it examines topics largely neglected in the public international law scholarship, such as space debris and the harmful interference of satellite services with ground-based astronomy

(dark and quiet skies). Yet the analysis is not simply theoretical; in each case the authors “propose practical solutions” to the grand challenges they identify, and offer novel and policy-relevant approaches to current over-exploitative practices. Third, it engages with the latest trends of state practice in this field through extensive analysis of state policies, position papers, and submissions before the relevant United Nations bodies and international institutions instead of focusing solely on international legal instruments. By “propos[ing] practical solutions” to the selected grand challenges, the book offers novel points of reflection concerning space sustainability to redress the effects of currently over-exploitative practices (p. 10).

Divided into eight chapters, it covers six main areas: space tourism (Chapter 1); mega-constellations of satellites (Chapters 2–3); the legal challenges posed by discarded rocket bodies (Chapter 4); space mining (Chapter 5); planetary defense (Chapter 6); and anti-satellite weapons (Chapters 7–8). In each area, the authors provide relevant scientific and technical backgrounds to clarify the relevant characteristics of both the outer space environment and current and foreseeable space technology. This context is essential to appreciate the policy strategies of space actors (both states and private actors) and their impact on the international community, which in turn affect the development of the related legal frameworks.

A distinctive feature of the book is that the authors do not develop an overarching thesis linking the various chapters to each other. In spite of this, a discernible common theme among the first six chapters is the authors’ emphasis on the perceived over-exploitation of the outer space environment by individual states and private actors with insufficient consideration for the legitimate interests of the international community as a whole. The final two chapters evaluate state responses to a series of security threats and their potential implications for the development of international law. It is also noteworthy that the authors place their inquiry into the context of “global environmental politics” (p. 7) where “the Space and Earth environments

¹ THE INSTITUTIONS OF EXTRATERRESTRIAL LIBERTY (Charles S. Cockell ed., 2022).

constitute a single interconnected environment” (p. 9), although this conceptual premise is not reflected in the book’s title, which evokes academic debates surrounding the issue of ownership rights in outer space. Conventional approaches to the study of space sustainability tend to consider outer space as a unique ecosystem with distinctive physical characteristics, as such regulated by a dedicated set of international treaties. Conversely, considering outer space as part of the Earth environment and vice versa provides a greater understanding of the interdependence of these two physical environments, and how human activities in outer space unavoidably affect (positively or negatively) this relationship. Equally, it shows that activities of individual actors in outer space that negatively affect the outer space environment may have repercussions for humanity as a whole. Adopting this angle of inquiry thus invites a reconceptualization of the relevance, and adequacy, of national and international laws and policies regulating the exploration and use of outer space with a view to securing safe and equitable uses of outer space by all states.

Throughout the book, the foundational idea of “global challenges” appears to have a meaning and connotations taken for granted. As a result, at times it remains marginal to the analysis. For example, the opening chapter on the legal challenges posed by space tourism focuses on whether the duty to rescue astronauts also applies to space tourists, who are not necessarily professionally trained astronauts. By examining the practice of private U.S. companies, and through detailed application of the rules of treaty interpretation to relevant legal texts, the authors argue that the duty to rescue astronauts equally applies to “non-governmental crew members” (p. 31), including passengers on a commercial spacecraft (p. 34). Undoubtedly, the analysis *per se* is rich and informative. Yet space tourism is not a topic intuitively associated with “a grand challenge for humanity.” The authors write that the topic’s relevance lies in the environmental risks posed by space tourism—namely, the changes in the atmosphere caused by carbon and other emissions—posed by a growing number of space tourism flights (“it is all a question of

volume,” p. 41). However, the legal analysis does not delve deeply into any aspect of the perceived environmental risks, hence it does not clarify the nature of space tourism as a grand challenge.

Notwithstanding this gap in the analysis of space tourism, the novel idea of “grand challenges” serves the function of a legal construct providing a broad rationale for the analysis of the selected outer space activities. It thus provides the analytical lens through which to evaluate how activities by individual actors (public or private) affect outer space as a single interconnected environment, potentially generating negative impacts for humanity as a whole. The identified grand challenges can be grouped into three types: outcome-oriented; normative; and anticipatory.

Outcome-oriented grand challenges emphasize the indiscriminate effects of the perceived over-exploitation of outer space by individual actors to the international community as a whole. The authors identify the effects generated by the deployment of mega-constellations of satellites as the prime example. These mega-constellations can include thousands, or even tens of thousands, of satellites, which provide high-bandwidth Internet service around the world. Their increasing numbers can cause the congestion of low-Earth orbits (LEOs), risk of collision with other space objects, generation of space debris, and harmful interference with ground-based astronomy generated by light pollution (p. 50). In Chapter 2, the authors argue that, being a LEO part of Earth’s environment, “[m]ega-constellations are on track to exceed the limits of that environment, with negative consequences for all of humanity” (*id.*). Having statistically probed that the current levels of space debris are already outpacing the cleaning capacity of atmospheric drag, they recommend constructing mega-constellations out of fewer satellites (p. 62) and avoiding the saturation of large parts of the orbital shells, or collections of circular orbits having the same altitude, by single operators (p. 70). This discussion provides one example of how scientific insights can greatly enrich the analysis and inform policy. On point of law, the analysis in Chapter 3

shows the presence of gaps in the international legal frameworks (hard law and soft law) applicable to collisions involving mega-constellations, such as a bespoke regime of liability for damage, as well as the harmful effects of the light pollution generated by mega-constellations to ground-based astronomy. A similar logic applies to the assessment in Chapter 4 of the harmful consequences (both environmental and entailing liability for damage) caused by discarded rocket bodies. The authors include the generation of orbital debris and the potential to cause damage to people and property following an uncontrolled re-entry to Earth. This leads them to recommend the inclusion of controlled re-entry plans in mission designs (p. 126), coupled with the negotiation of a new international treaty in this field (pp. 127–29).

Normative grand challenges focus on the potential law-making effects of currently unregulated space activities performed by groups of like-minded states. Space mining is the most prominent example. Chapter 5 evaluates the extent to which the actions by individual states (and the private actors within their jurisdiction) constitute relevant subsequent practice “in support of an interpretation of the [Outer Space Treaty] that would allow for property rights in extracted resources” (pp. 131–32).² The authors argue that, while the Outer Space Treaty does not specifically address space mining, states remain bound by the duty of due regard for the corresponding interests of other states (p. 138). They also point out that treaty obligations are open to interpretation and individual states implement them according to their own understanding (p. 139). This means that states possessing space mining technology are in a position to initiate a potential process of custom-creation through their activities. In order to stop this trend, the authors recommend the negotiation of an international treaty on space mining (*id.*).

² Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, Jan. 27, 1967, 610 UNTS 205 [hereinafter Outer Space Treaty].

Anticipatory grand challenges aim at preventing (as opposed to redressing) the occurrence of a potentially indiscriminate, harmful event. Some anticipatory challenges require advance planning on the part of states. One such challenge is planetary defense, which involves “the detection, characterisation, risk assessment and, if necessary, deflection or destruction of asteroids and comets that have the potential to strike Earth” (p. 186). Chapter 6 provides a detailed overview of the types and characteristics of asteroids and comets, including an accessible explanation of detection and deflection techniques. This is very useful to understand the degree of threat associated with the potential impact of those celestial bodies and the related scale of deflection operations. The authors persuasively claim that planetary defense deals with “life-and-death situations” (p. 220). It follows that elementary considerations of humanity underpin the obligation of states to share information concerning near-Earth objects (NEOs) at risk of impacting the Earth as well as the duty to assist states lacking the means to perform a deflection mission of a NEO showing a trajectory to impact in their territory (p. 222). This type of preventive grand challenge requires international coordination. Accordingly, a recommended policy action is to develop “mission-ready planetary defence assets” (p. 250).

Other anticipatory grand challenges require collective responses. This is the case of anti-satellite (ASAT) weapon tests, such as those recently conducted by China (2007), India (2019), and Russia (2021). As Chapter 7 demonstrates, ASAT tests generate potentially long-lasting space debris, thus posing an indiscriminate threat for the space activities of other states. In Chapter 8, the authors develop an original argument showing that recourse to ASAT weapons in self-defense does not appear to comply with the requirements of necessity and proportionality under the international law on the use of force (p. 354). After rigorously documenting a widespread and almost univocal reaction by states against the most recent ASAT tests by China, India, and Russia, the authors conclude that a rule of customary international law establishing

the unlawfulness of the intentional creation of long-lasting space debris is crystallizing. Equally, recourse to ASAT weapons as part of an ongoing armed conflict is likely to violate the *jus in bello*, due to their generation of an indiscriminate—hence disproportionate—attack through scattered space debris (p. 357). Such practices require as widely and unequivocal a condemnation as possible by the international community, since they potentially count as subsequent state practice in the interpretation of Article IV of the Outer Space Treaty, which prohibits the conduct of military activities in outer space.

The breadth and scope of the analysis developed around the three types of grand challenges is impressive. However, considering the largely international and cooperative character of space activities, one might question whether the significant emphasis placed by the authors on U.S. space activities, including those performed by private actors, throughout the book is justified. Similarly, on occasion the legal argument put forward is not entirely convincing. For instance, in Chapter 6, the authors argue that the duty to assist states located in the predicted impact area of a NEO finds support in international agreements acknowledging the duty to rescue, including Article V of the Outer Space Treaty (p. 225). This is counterintuitive, considering that Article V of the Outer Space Treaty and planetary defense activities operate on distinct conceptual levels. The former covers activities pertaining to the exploration and use of outer space by astronauts that have not gone according to plan. The latter refers to a natural phenomenon originating in outer space but posing threats to Earth (in terms of causing damage to people and their property). Subsuming it within the scope of application of Article V of the Outer Space Treaty does not find support in either the text of the treaty, its negotiating history or subsequent state practice (including the negotiation, adoption, and application of the Rescue Agreement³). In particular, it is difficult to

³ Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space, Apr. 22, 1968, 672 UNTS 119.

appreciate how the humanitarian duty to rescue astronauts can be extended *mutatis mutandis* to the population affected by a NEO impact. Resort to international disaster law⁴ appears to be a more straightforward, intuitive solution to cope with such scenarios.

Another example of a contestable argument is the characterization of astronomy as a form of space exploration and use of outer space. Absent any indication to the contrary, the authors argue that “activities in the exploration and use of outer space can include activities on Earth’s surface, such as astronomy” (p. 101). Such an interpretation appears unpersuasive, since no debate in the recorded negotiating history of the Outer Space Treaty refers to activities conducted from Earth as constituting a form of exploration and use of outer space. Nor does the letter of the Treaty itself. If, as the authors argue, mega-constellations of satellites cause harm both to the “states that host, operate or support major observatories” and “all humankind” (p. 113), then this entails a form of responsibility for damage currently not contemplated by either the Outer Space Treaty or the Liability Convention⁵—namely, responsibility for damage caused on Earth by an object in outer space, potentially to humanity as a whole. The latter, as the negotiating history of the Moon Agreement shows, is not recognized as a subject of international law.⁶

An aspect of the analysis that remains somehow inconclusive, and would have benefitted from more theoretical probing, concerns the extent to which the Outer Space Treaty addresses the issue of property rights over resources extracted from celestial bodies (Chapter 5). Having concluded that the rules of treaty interpretation contained in Articles 31–32 of the

⁴ For an overview of this emerging field of law, see Arnold Pronto, *International Disaster Law*, in THE OXFORD HANDBOOK OF THE INTERNATIONAL LAW OF Global Security 566 (Robin Geiß & Nils Melzer eds., 2021).

⁵ Convention on International Liability for Damage Caused by Space Objects, Mar. 29, 1972, 961 UNTS 187 [hereinafter Liability Convention].

⁶ Agreement Governing the Activities of States on the Moon and Other Celestial Bodies, Dec. 18, 1979, 1363 UNTS 3 [hereinafter Moon Agreement].

Vienna Convention on the Law of Treaties⁷ do not clarify the meaning of the term “national appropriation” in Article II of the Outer Space Treaty, the authors identify the Moon Agreement as evidence of subsequent agreement in the interpretation of that term (p. 144). Adopted in 1979, the latter is the only multilateral treaty on outer space that addresses the issue of space resource utilization by requiring the creation of “an international regime . . . to govern the exploitation of the natural resources of the Moon as such exploitation is about to become feasible” (Article 11, paragraph 5). A peculiarity of the Moon Agreement is that it describes the Moon and its natural resources as “the common heritage of mankind” (Article 11, paragraph 1), effectively establishing their legal status as common property of humanity. Due to the opposition to the concept of common heritage of mankind by several states, both during the treaty negotiations and after its conclusion, the Moon Agreement is the least successful of the UN treaties on outer space, having been ratified by only seventeen states. Against this background, the analysis carried out in Chapter 5 appears contradictory. On the one hand, the authors argue that the drafting history of Article 11 of the Moon Agreement is of no assistance to the interpretation of the Outer Space Treaty concerning property rights (p. 145). On the other hand, they write that “[t]he need for negotiation on Space mining was accepted by all the members of [the UN Committee on the Peaceful Uses of Outer Space] . . . as well as all the members of the UN General Assembly, which adopted the Moon Agreement without a vote (i.e., by consensus) in 1979” (p. 149). This statement suggests that consensus at the General Assembly is synonymous with unanimous acceptance of a resolution by states. However, this does not find support in either UN practice or the scholarly literature.⁸

⁷ Vienna Convention on the Law of Treaties, May 23, 1969, 1155 UNTS 331.

⁸ For a detailed analysis of the role of consensus in the practice of the UN General Assembly, see ROSSANA DEPLANO, *EMPIRICAL AND THEORETICAL PERSPECTIVES ON INTERNATIONAL LAW: HOW STATES USE THE UN GENERAL ASSEMBLY TO CREATE INTERNATIONAL OBLIGATIONS* 83–94, esp. 86–87 (2022).

Yet it does not clarify whether ultimately the Outer Space Treaty confers or prohibits property rights over extracted resources.

A related, and contentious, aspect of the analysis is the reference to the Artemis Accords, which is a set of policy recommendations guiding the execution of the forthcoming Artemis missions on the Moon by a group of states.⁹ A peculiarity of the Artemis Accords is that they are intended to “implement the provisions of the Outer Space Treaty” (preamble, paragraph 10). The authors describe the Artemis Accords as “not that significant” as either subsequent practice in the application of the Outer Space Treaty or as relevant state practice and *opinio juris* for the purposes of custom creation” (p. 159). In particular, they consider Section 10 of the Artemis Accords—which states that “the extraction of space resources does not necessarily constitute national appropriation under Article II of the Outer Space Treaty”—to be ambiguous in relation to the concept of national appropriation (pp. 159–60), effectively sanctioning the power of unilateral action on space resource utilization by spacefaring states. They write that “[t]he postponement of negotiations [of an international treaty on space mining] until rules and practices can be shaped by a small group of like-minded states is one of the tried-and-tested strategies for hegemonic law-making” (p. 175, emphasis added). In doing so, the authors align themselves with other critical voices,¹⁰ which is part and parcel of a healthy academic debate. At the same time, this qualification of the Artemis Accords does not appear convincing in the light of the current number of signatories—forty-three in total, all parties to or signatories of the Outer Space Treaty (except one), of which seven have also ratified the Moon Agreement, three have signed it and one has withdrawn from it after signing the Artemis Accords. Given the diversity of the

⁹ The Artemis Accords: Principles for Cooperation in the Civil Exploration and Use of the Moon, Mars, Comets, and Asteroids for Peaceful Purposes, Sept. 13, 2020, 62 ILM 893.

¹⁰ See, e.g., Sa’id Mosteshar, *Artemis: The Discordant Accords*, 44 J. SPACE L. 591 (2020); Stephan Hobe, *The Artemis Accords: What They Mean for the Development of International Space Law*, 70 ZLW 1 (2021).

Artemis Accords signatories, which represent all continents, and the contextual limited number of ratifications of the Moon Agreement,¹¹ the mere reference to “a small group of like-minded states” (*id.*) does not appear to be a reason sufficiently robust to equate *in situ* resource extraction in support of the long-duration scientific missions on the Moon with a strategy of hegemonic law-making taking place in a legal vacuum.

Overall, such imperfections do not detract from the value of the analysis. *Who Owns*

Outer Space? is a source of original, out-of-the-box thinking carved out of a rare encounter with multidisciplinary analysis at the crossroads of astrophysics, policy, and law. This makes it particularly suitable for the space law and policy readership of academics (especially post-graduate students and above) and practitioners.

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¹¹ COPUOS, Legal Subcommittee, Status and Application of the Five United Nations Treaties on Outer Space, and Way and Means, Including Capacity-Building, to Promote Their Implementation, at 10, UN Doc. A/AC.105/C.2/2024/CRP.3 (2024).